INJECTION-TRIGGERED OCCLUSION OF FLOW PATHWAYS AND ITS REMEDIATION IN MEZÖBERENY-HUNGARY

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Keywords: Injection Problems, Clogging, Bekes Basin, Soft Stimulation.

ABSTRACT

Reasons for injectivity decline were investigated at a geothermal site located in SE Hungary. Due to low injectivities, production rates have to be reduced and the site faces negative commercial implications.

In addition to historical operation data, fluid and rock samples were sampled on-site and further investigated in the laboratory. Analysis and experiments focus on physical, chemical and biological processes and their interaction.

Results show five main processes being responsible for injection-triggered occlusion of flow pathways: Reservoir thickness, low permeability in the reservoir, precipitation of minerals, microbiological activity and fines migration. The reservoir geometry indicates unfavorable conditions like low sandstone thickness and low permeability. Fines migration is caused by washouts in loosely cemented rocks, from where fine sand or clay particles are transported and injected into lower aquifer layers. Precipitation of minerals is caused by cooling or oxygen exposure. Biofilm is a result of sulfate-reducing bacteria being present at injection depth. Biofilm and physicochemical conditions also cause corrosion in pipelines and wells.

In order to fully understand the processes taking place in the injection well, borehole measurements will be done in 2019. After evaluating the results, a specially tailored stimulation concept will be applied in the injection well. A combined chemical-mechanical treatment will take place at different depth. Borehole measurements and hydraulic tests will be done again after the stimulation to show the effect of the stimulation. A multiple monitoring and sampling program comes along with activities onsite.

1. INTRODUCTION

Injection into geothermal aquifers can lead to clogging of highly permeable flow-paths by small particles. We study clogging processes in a low-enthalpy geothermal aquifer in Hungary using fluid and solid analysis as well as operational data. Clogging processes in geological media are often related to field operations and artificially intruded materials. However, which processes are triggered by field operations, how the different processes interact and the subsequent implications for flow-paths are not yet fully understood.

This study is carried out in the framework of the EU-funded project DESTRESS (Demonstration of soft stimulation techniques of geothermal reservoirs). In this project, sites in different geological settings are studied in order to afterwards demonstrate the best stimulation technique. The key goal of DESTRESS is to demonstrate the success of stimulation treatments in long-term enhanced productivities and injectivities.

2. STUDY AREA

Geothermal potential of the Pannonian Basin and its utilization has a long tradition in Hungary. The main aquifers are carstified Mesozoic rocks and Pannonian sandstones. Injection into the sandstones has a relatively short history in Hungary.

The Mezőberény geothermal site was constructed in 2011-2012, with the aim to utilize the geothermal potential in the Békés Basin for district heating. The system consists of one production well (B-115) with a depth of 2003 m, and one reinjection well (K-116) with a depth of 2001 m. After a three-weeks operation, injectivity radically dropped, which lead to a stop of operation. In 2017 a mechanical and chemical cleaning campaign was carried out to remove clogging material, but a long-term solution for injectivity increase has not been found yet (Siklósi, 2017).

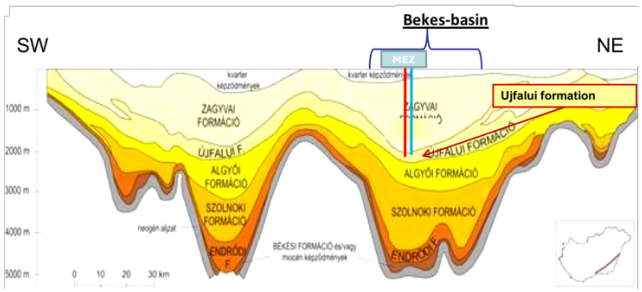

Figure 1: Geological profile and location of the site in the Bekes basin (modified from Junasz, 1994)

3. APPROACH

The database compiled during this study consists of water and gas samples from different points in the thermal loop, drill cores, filter residual and historical operational data. Samples have been analysed using various methods in order to understand physical, chemical and biological processes in the reservoir.

Based on sample and data analysis, a stimulation program was designed. The stimulation aims at a long-term injection enhancement at the site. The program consists of pre-stimulation borehole measurements, a chemical soft-stimulation and post-stimulation borehole measurements.

4. POSSIBLE INJECTION PROBLEMS

Five different injection problems have been identified at the Mezöbereny site: Reservoir thickness, low permeability in the reservoir, precipitation of minerals, microbiological activity and fines migration.

The reservoir thickness was analysed based on lithological data from deep wells in the Békés county. According to the literature, the reservoir formation is thickening towards south-east. Lithological data suggest that the Mezöbereny wells do not fully intersect the reservoir formation.

Permeability of the reservoir has been analysed using production test data and well logs. The permeability of the sandstones ranges between 20 and 220 mD. The near wellbore permeability is according to flowtests 1.8E-13 m^2 and the effective reservoir permeability is 8.7E-14 m^2. Moreover, 70% of the injected water flows into three of 12 filter sections.

Figure 2: Core samples from nearby wells from 1500-1900 m

Possible mineral precipitation is analysed using water composition, gas composition and rock composition combined in a hydrochemical model. The total salinity of the water is 1855 mg/l with Na and HCO3 as major ions. The gas phase is mainly composed of CH4, while rocks contain quartz, feldspars, carbonates and clay minerals. The hydrochemical model suggests mainly carbonate and iron rich minerals to precipitate. A contact with oxygen generally increases the saturation indices of supersaturated minerals.

The total organic content was measured to be 1360 mg/l while the phenol index is 5540 µg/l. Both provide good circumstances for bacteria population in the wells. Bacteria detected at the site are sulphate-reducing (Desulfotomaculum, Desulfobulbus) and methanogene (Methanosarcina, Methanospirillum) groups. These bacteria can form biofilm or cause corrosion on the well casing.

Fines migration could not be proven by data yet but is expected due to high clay content in some reservoir layers. Fines which are injected into the aquifer can clog free pore spaces near to the wellbore.

5. REMEDIATION STRATEGY

The reasons for the decline in injectivity at VS-1 has been analysed based on available data. For a more detailed analysis, adequate measurements and investigations have to be performed. Only then, further information on the status of the well and the reservoir will be available. The results of the logging before treatments will show the condition of the well. Based on that, the stimulation plan might be adopted. In long term, the operator of the plant will take action to counteract the causes for injectivity decline.

The works will be performed in three steps, which are Pre-stimulation measurements, Stimulation and Post-stimulation measurements. The operation is divided into two separate groups. Group 1 includes hydraulic tests and stimulation. This also covers production and injection tests, stimulation of borehole, cleaning lifts and all needed preparational work at the site (e.g. wellhead, fencing, lighting, piping, tanks...) as well as recultivation. Additionally, group 1 should take and analyse fluid and solid samples, supervise activities onsite and coordinate works from group 1 and group 2. Group 2 includes borehole-logging and bailer sampling before and after wellbore-testing, flowmeter-measurements during production and injection tests, logging in production well during tests in injection well.

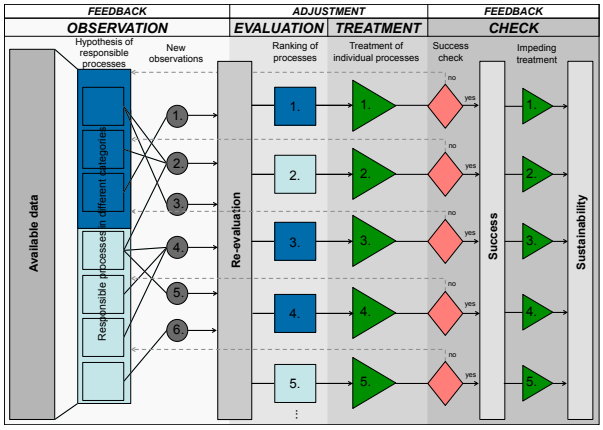

Figure 3: Schematic picture of the Feedback Adjustment Procedure according to Brehme et al. 2017

The operations will for the first time apply the Feedback Adjustment Procedure, that ensures a sustainable soft stimulation (Brehme et al., 2017). The procedure started with analysing all available data and evaluating and ordering potential injection problems. Any new observation during the observation requires a re-evaluation of processes based on an updated database. The stimulation treatment is tailored to wellbore conditions and aims for removing any injection hindering process. One important step in the procedure is a re-evaluation loop after each treatment that ensures regularly updated knowledge on site-specific processes. The loop ensures an adapted stimulation concept which considers interaction of different processes ending in sustainable reservoir enhancement. A final check of wellbore and reservoir conditions verifies that the treatments overcame formation damage.

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Acknowledgements (optional)

Activities are taking place in the frame of the DESTRESS project. The DESTRESS project has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement No 691728. The authors gratefully acknowledge all cooperations and works taken place within the DESTRESS community.